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SIDERITIC CONCRETIONS IN ILLINOIS SHALE, GRAVEL, AND TILL

J. E. Lamar and Norman C. Hester

ABSTRACT

Sideritic concretions occur in Illinois shale, gravel, and till deposits. Other ferruginous concretions believed to have resulted from the weathering of siderite concretions occur in some gravel deposits.

The physical structure, mineralogy, and chemical composition of a number of sideritic concretions are reported. X-ray, petrographic, and chemical analyses indicate that the concretions consist principally of siderite, various amounts of clay minerals, quartz silt, calcite, and hydrated iron oxide. Oxidation of the concretions ranges from slight to complete. Calcite veinlets in the concretions are believed to be filled syneresis cracks. Two large nodules have an unusual internal structure; one of them contains black sphalerite.

An extensive bibliography relating to sideritic concretions appears at the end of the report.

SIDERITIC CONCRETIONS IN ILLINOIS SHALE, GRAVEL, AND TILL

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INTRODUCTION

Sideritic concretions, sometimes called ironstone or clay ironstone concretions, occur in many Pennsylvanian shales in Illinois (Lamar, 1938). Concretions are also found on dumps accumulated during coal mining in the vicinity of Wilmington, Coal City, Braidwood, and Essex. Fossil plants and animals in sideritic concretions from the Francis Creek Shale Member of the Carbondale Formation (Pennsylvanian) near Mazon Creek, referred to as the Mazon Creek flora and fauna, are world renowned. The more recently found concretions from the Wilmington Pit II workings are now equally as famous as the old Mazon-Braidwood collections (Charles Collinson, personal communication, 1971). Sideritic concretions, or what are believed to be the weathered remains thereof, occur in various degrees of abundance in some Illinois gravel deposits. Concretions are also found in till.

The results of a preliminary study that was prompted by a dearth of information regarding the mineralogical and chemical nature of sideritic concretions in general and of Illinois sideritic concretions in particular are given in this report. Although it deals with only a limited number of specimens and occurrences, it is hoped that it will lead to further exploration and appraisal of what appears to be an interesting field for geologic investigation. The distribution of the sideritic concretions or their weathered equivalents in Illinois gravel and till deposits, the degree to which they have been weathered, their relation to specific concretion-bearing shale deposits and to the glacial history of the gravel deposits, and their stability in concrete exposed to the weather, all merit more extensive study.

Most, if not all, of the Illinois concretions probably originally occurred in shales of Pennsylvanian age and, regardless of their present mode of

occurrence, were derived from this source. Glaciers plucked masses of concretion-bearing shale from the bedrock, incorporated them with other ice-borne materials, and deposited the mixture as till. The action of running water on the rock load of the glaciers is primarily responsible for the presence of the concretions in certain gravel deposits of the state.

PREVIOUS INVESTIGATIONS

The bibliography at the end of this report covers much of the literature regarding sideritic concretions. Papers whose titles suggest that they are devoted primarily to discussion of the biota of particular nodules have been excluded. The primary concern of most writers prior to 1960 was the genesis of the concretions rather than their composition, detailed mineralogy, or internal structure. Several lines of evidence were interpreted as pointing to a syngenetic origin. Composition was indicated as siderite and clay, with calcium carbonate present locally, but no analytical data were given. Veins of pyrite, gypsum, sphalerite, calcite, or other minerals in the concretions were considered to have been emplaced after, rather than during, concretion formation. According to Lesquereux (1870) formation of a concretion began around a "central nucleus," such as a leaf, stem, or other part of a plant, or, more rarely, around fishbones or the remains of insects and crustacea. Most writers assumed a chemical concentration or accretion of iron carbonate from sea water took place around the nucleus, but Lesquereux favored the action of Infusoria or *Bacillaris* as the precipitating agents.

Lucas (1873) suggested that all clay ironstone lying in beds of the Carboniferous formations were formed in peaty or nonpeaty stagnant lagoons on the alluvial flats of deltas and that the cracks seen in the beds of clay ironstone were formed when the pools dried up.

The environment of formation, according to Tyler (1950), was "brackish marine waters or in marine swamps where abundant decaying vegetation inhibited oxidation of the iron and promoted the formation of siderite." The presence of iron in the marine waters was a common assumption. Neither whether nor why there was an apparently abnormally high concentration of iron was considered.

More recently, Franks (1969), who studied the clay ironstone concretions of the Kiowa Formation in Kansas, suggested a different mode of origin. He concluded that the cracks in the Kansas concretions are like the syneresis cracks found in argillaceous sediments, that they were formed diagenetically by the dewatering of colloidally precipitated iron carbonate soon after deposition of the mud enclosing them, and that the source of the iron in the concretions probably was "coatings of iron oxide or hydrated ferric oxide on the detrital clay micelles that make up illitic Kiowa shale."

In a 1970 paper relating to the fauna of the Francis Creek Shale in the vicinity of Wilmington, Illinois, Johnson and Richardson (1970) postulated the rapid deposition of some parts of the shale and the formation of concretions as firm bodies shortly after burial, before complete anaerobic decomposition of the plant and animal remains enclosed in them. They believed that

many undecomposed animals retained their three-dimensional fullness, and their subsequent decomposition resulted in "cavities that were later filled by calcite, sphalerite, kaolin, pyrite, and, rarely, galena."

Shabica (1970), in a discussion of the depositional environments of the Francis Creek Shale in northern Illinois, indicated that sideritic nodules are abundant only in the interdistributary bay sediments of the shale.

A paper by Horne, Swinchatt, and Ferm (1971) related the "sideritic ironstone" in Pennsylvanian strata in eastern Kentucky to the cessation of detrital influx in lagoonal "bay fills."

Sellwood (1971), writing about "semicontinuous bands of mudstone cemented by impure siderite," considered that the siderite "was selectively precipitated close to successive sediment/water interfaces which mark minor non-sequences."

Zaritskiĭ (1959) described the sideritic concretions of the coal beds and associated strata in the Donets Basin and suggested that the chemical and mineralogical nature of the concretions is governed by the facies of the surrounding rocks. He mentions (1959, p. 97) 14 articles in the Soviet periodical literature on the extensive occurrence of siderite in the form of concretions in coal-bearing deposits.

SAMPLES STUDIED

Gravel Used in Champaign-Urbana

Gravel reportedly from an out-of-state source is used as a ground cover in Champaign-Urbana. A random collection of brown pebbles was made from gravel so used in front of the Natural Resources Building and from other sources. The sample is subsequently referred to as NRB.

Central Illinois

"Ironstone" pebbles have been specifically reported in small percentages in gravel by Anderson and Hunter (1965), Hunter (1966), Hester and Anderson (1969), and Hester (1970) in central Illinois, and they have been observed in other parts of the area. As there was evidence that some of these pebbles were originally sideritic concretions, a composite sample of ironstone pebbles was obtained for study from gravels in the central and eastern part of the state. This sample is referred to as the central Illinois sample.

Nodule from Till Near La Salle

A rounded boulder about 5½ x 8 x 13 inches was obtained from a boulder pavement at the base of till in an excavation in the SE¼ NW¼ NE¼ Sec. 28, T. 33 N., R. 1 E., La Salle County. The boulder is a concretion.

Siderite from Cores

Pieces of siderite from three diamond drill cores from Livingston, McLean, and Jackson Counties, were included in the study. The siderite occurs in Pennsylvanian shale. The siderite, subsequently referred to as the core sample, comes from Livingston County.

Concretions from Shale Outcrop

A collection of concretions from an exposure of shale along Covel Creek in the NW¼ SW¼ Sec. 27, T. 33 N., R. 3 E., La Salle County, was taken about 1 foot back from the exposed face of the shale. The outcrop is described in detail in Illinois Geological Survey Bulletin 66 (1942, geologic sec. 8, p. 289). In the present report the sample is called the Covel Creek sample.

Concretions from Mine Dumps

Concretions from the shale in four abandoned mine dumps in Grundy and Will Counties were investigated. The samples were taken some years ago and whether the dumps are still extant is not known. Survey sample numbers precede the locations.

NF 434, SE¼ SE¼ Sec. 9, T. 33 N., R. 8 E., Grundy County
NF 435, W½ Sec. 29, T. 33 N., R. 8 E., Grundy County
NF 436, SE¼ SW¼ Sec. 32, T. 33 N., R. 9 E., Will County
NF 437, SW¼ SE¼ NW¼ Sec. 5, T. 32 N., R. 9 E., Will County

The samples referred to as Coal City 1 and 2 were nodules from sample NF 436.

CHARACTERISTICS OF CONCRETIONS

Calcite Veins

In the descriptions that follow, reference is made to the veins of calcite that occur in some concretions. These were particularly well developed in the concretions obtained from the shale outcrop, were absent in the concretions from the central Illinois gravel deposits, and were uncommon in the concretions from Grundy and Will Counties and sample NRB.

The origin of the veins is not definitely known, but, as was suggested by Franks (1969), they may be calcite-filled syneresis cracks that were formed while the iron carbonate of the concretions was still a gel. The cracks resemble the syneresis cracks that develop in clay-water systems (White, 1961).

Description of Samples

Sample NRB

Brown sideritic pebbles representative of the sample were mixed with cement and made into a concrete slab. The slab was sawed in half parallel to its two largest sides, thus exposing the interiors of 36 pebbles, which are described below.

Material	Number of pebbles	Percent of sample
Reddish brown sideritic nodules	14	39
Very dark gray sideritic nodules	14	39
Medium brown sideritic nodules with peripheral zonation	6	17
Gray sideritic nodules	2	5

None of the pebbles have the prominent oxidized marginal zones that were common on the pebbles studied from other sources. Instead, a very dark brown zone about one sixteenth of an inch thick characterized the margins of the pebbles. One of the dark gray sideritic nodules contained scattered small grains of pyrite and an irregular vein of white calcite. Two other sideritic pebbles also contained calcite veins. These veins are discontinuous, with the end of one segment of a vein overlapping the next. Similar veins have been noted in other pebbles not specifically mentioned in this report.

Central Illinois Sample

The so-called "ironstone" pebbles in the central Illinois sample are brown, yellow-brown, or yellow, and some are comparatively light in weight. Some of them are rounded, others irregular in shape. Some have a dull exterior, but others have a slight gloss. Some consist of a comparatively hard outer "rind" with a more or less hollow interior. Others consist of relatively firm concentric yellow or brown bands or irregularly distributed septa of yellow-brown to dark brown material. The hardness of the septa varies. The septa often partition the interior of the pebbles into compartments of various sizes. The differences in the color of the septa may relate to differences in the physical state or mineralogical identity of the material composing them. Yellow clay or quartz silt may occur in some of the cavities created by the septa. Broken pieces of compartmented pebbles also have been observed in some gravel deposits.

A few pebbles have a central mass or core that is gray. In some of the pebbles the core is discrete; in others it grades into a surrounding mass of yellow or brown material that in many pebbles is powdery. X-ray diffraction studies of two samples of the gray core material showed it to be principally siderite.

The brown or yellow pebbles and the broken fragments are believed to be former sideritic concretions that have undergone various degrees of weathering. The gray cores are regarded as being unoxidized remnants of the original concretions. The yellow powder, the septa, and the outer rind are hydrated iron oxide of various degrees of purity and in various physical states. They may also differ mineralogically.

La Salle Nodule

The sideritic nodule taken from exposed till near La Salle has a brown exterior with an exfoliated appearance owing to the spalling of banded deposits of iron oxide that made up its exterior rind. One end is roughly flat and apparently marks the site of a former calcite-filled syneresis crack, or cracks.

Internally, the nodule displays two essentially unconnected areas of oxidation, visible in figure 1. The oxidation has taken place around syneresis cracks that are wholly or partly filled with calcite. In some of the cracks calcite crystals have corners rounded as though they had been acted upon by solution. A second stage of calcite deposition is indicated by a thin, lighter colored deposit that lines some of the cracks.

The oxidized areas within the nodule and the outer rind are bands of various shades of medium to dark brown or reddish brown that are evidently iron oxide resulting from oxidation of the siderite of the nodule. Some of the bands are not well demarcated, but, where the banding is well developed, both inside the nodule and in the rind, between 12 and 14 bands can be distinguished. The contact of the oxidized areas with the fresh siderite is marked by a narrow band that is lighter brown than any of the others. Whether the bands are diffusion banding or are the result of different stages of oxidation during the history of the nodule is not evident, though the latter idea is favored.

Siderite from Cores

Several pieces of diamond drill core, consisting principally of shale but containing siderite bands, were examined. The siderite appears similar in all the cores sampled and is a dull medium brown. Its maximum thickness in cores examined was 1½ inches. The contacts with superjacent and subjacent shale are sharp in some pieces of core but gradational in others. When soaked in water, the shale disintegrated, but the siderite was left with a thin shale coating. Thin horizontal bands of siltstone cut through some of the siderite, suggesting that the siderite in the cores is a bedded rather than a nodular deposit. Some of the siderite bands seem to be free of impurities, but others contain mica flakes and appear to be silty.

Two samples were treated with hot concentrated hydrochloric acid. As soon as effervescence stopped they were greatly diluted with water and the insoluble material was allowed to settle. The insoluble residue was washed and recovered by decantation. One sample had a weight loss of 74 percent and the other lost 61 percent, presumably due mostly to the dissolution of siderite. X-ray diffraction showed the relative percentages of expandable clay minerals,

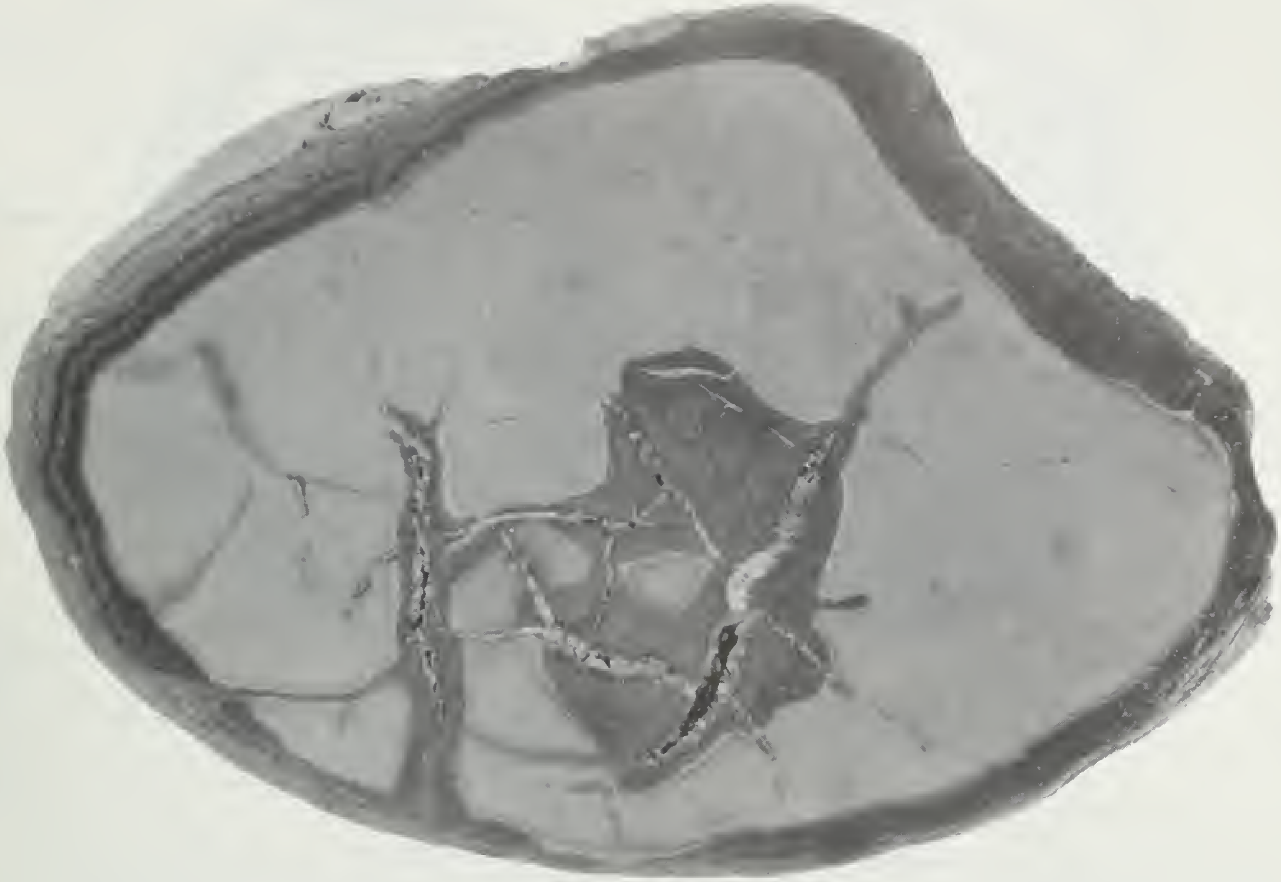

Fig. 1 - Cross section of a large sideritic concretion from a boulder pavement beneath till near La Salle showing the effects of weathering. The outer, weathered rind has numerous brown color bands, and a similar phenomenon is visible within the boulder. The veinlets are filled or lined with calcite and are believed to be syneresis cracks. Some oxidized bands within the boulder follow minute cracks, which are probably incipient syneresis cracks that contain no calcite. About four-fifths actual size.

illite, and kaolinite in the residues from the two samples were, respectively, 22, 35, and 43, and 22, 33, and 45.

Concretions from Shale Outcrop

The sideritic concretions from the shale outcrop ranged from 3 to 6 inches long, 1½ to 5 inches wide, and seven-eighths to 1½ inches thick. Externally, they are grayish brown. Six of the seven pebbles sectioned have a brownish gray center around which is a dark brown rind 1 to 2 mm thick. The seventh pebble has a gray center surrounded by a brownish gray zone that constitutes the bulk of the pebble and an exterior dark brown rind 1 to 2 mm thick.

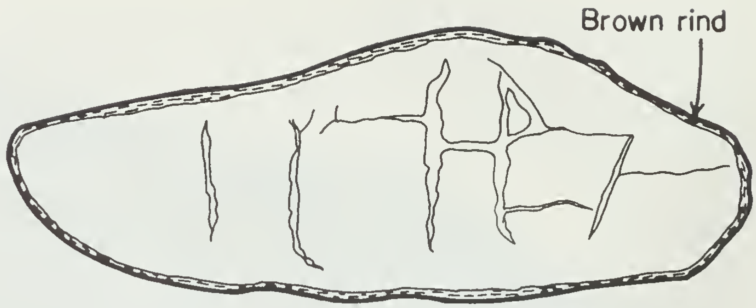

Fig. 2 - Vertical section of sideritic nodule showing laddering of syneresis cracks. Actual size.

Calcite-filled cracks, believed to be syneresis cracks, occur in all the pebbles, but their abundance varies. They range from thread-like to a maximum of about 2 mm wide and are best developed within the central part of the concretions. Very few cracks reach outward to the brown rind of the pebbles. Some of the pebbles show a pronounced "laddering" of the cracks in cross section (fig. 2); some also show the same effect in horizontal section (fig. 3). In a sawed cross section of a concretion the cracks are dominantly vertical (fig. 2), whereas in a horizontal section preferred orientation is less evident, although the longest cracks roughly parallel the longest dimension of some nodules.

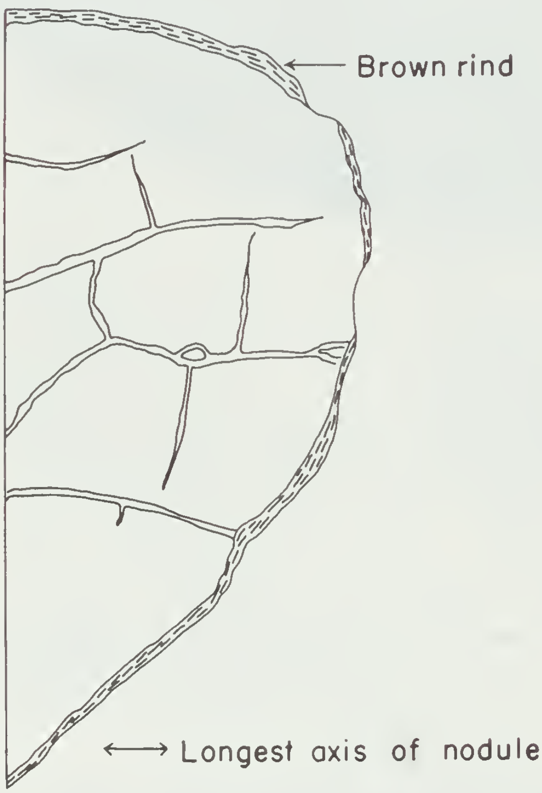

Fig. 3 - Horizontal section of part of sideritic nodule showing laddering of syneresis cracks. Actual size.

Most of the concretions exhibited one or more vertical, or nearly vertical, sides or edges that are roughly straight and perpendicular to the largest side of the nodule. They are thought to be the site of a former calcite-filled syneresis crack from which the calcite has been dissolved, after which breakage resulted. On the surface of one such abrupt face, created when one of the concretions broke during sawing, a small calcite-coated area remained that may well be the remnant of a calcite-filled syneresis crack. The rest of the newly exposed surface was gray brown, like the exterior of the rest of the pebble, suggesting that solution had acted on it for some time.

Concretions from Mine Dumps

Samples consisting of concretions collected from the surfaces of four old mine dumps in Grundy and Will Counties were, in general, flat or moderately rounded ovals, brownish gray, brown, or dark brown on the outside, depending on the extent of oxidation and exfoliation that had occurred. The largest nodule in the samples was about 6 inches long. Some of the nodules readily split parallel to their broadest side; such nodules

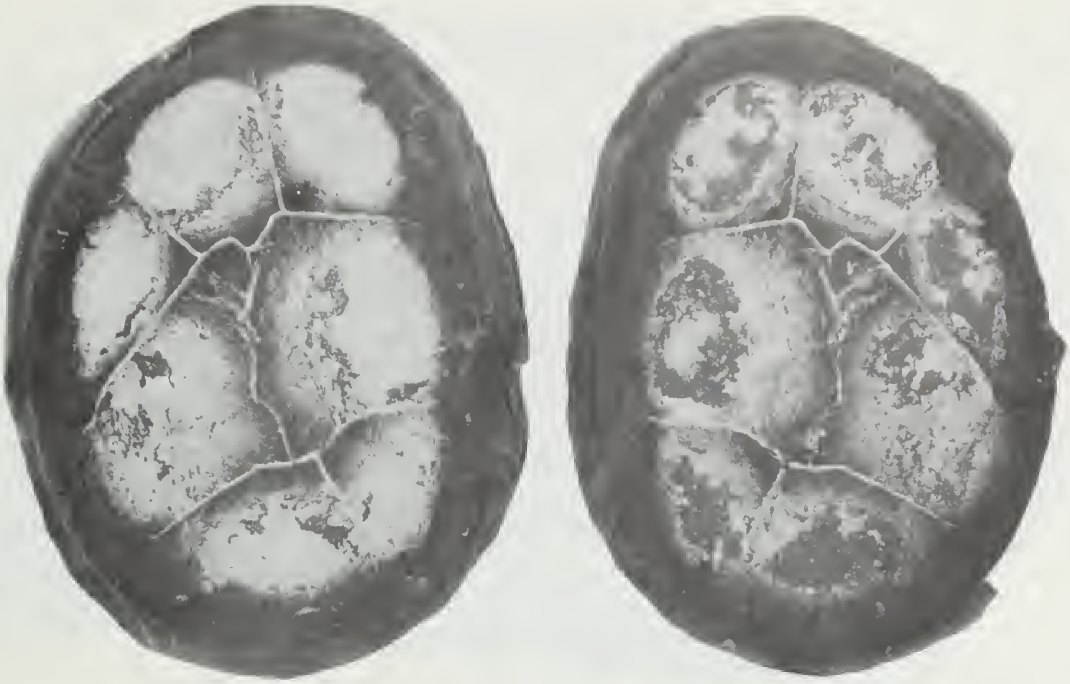

Fig. 4 - Matching halves of a sideritic nodule showing calcite-filled syneresis cracks, a coating of white kaolinite on the split faces, and prominent outer rind. X 1.1

have been known to contain leaf or animal imprints. Most of the nodules have a dark gray, structureless sideritic center surrounded by a rind that has one or two annular, dark brown zones ranging from a fraction of a millimeter up to about 8 millimeters thick. A few pebbles have abrupt ends, probably because they broke along syneresis cracks, but such cracks are generally rare and small.

One flat pebble, derived from the shale that overlies the Colchester (No. 2) Coal Member and found in a mine dump in the SE¼ SW¼ Sec. 32, T. 33 N., R. 9 E., near Coal City, is shown in figure 4. Calcite-filled syneresis cracks are evident. The white material seen coating the split faces in figure 4 is kaolinite. Bohor and Hughes (1971) reported a similar phenomenon.

Another concretion from the same mine dump showed calcite veins (fig. 5). Of all the concretions examined, this and the La Salle concretion were the only ones exhibiting two different stages of calcite emplacement.

Figure 6 shows the interior of an ovoid nodule and identifies its components. It has an outer sideritic shell within which a filling of sphalerite is accompanied by calcite. The genesis of the nodule probably involved the following steps:

1. A nodule (A and F) formed around remains of an animal that still retained some or most of its three-dimensional fullness. Subsequent decomposition of the animal tissue left a cavity. Such a process was suggested by Johnson and Richardson (1970, p. 53). The nodule was a firm gel.

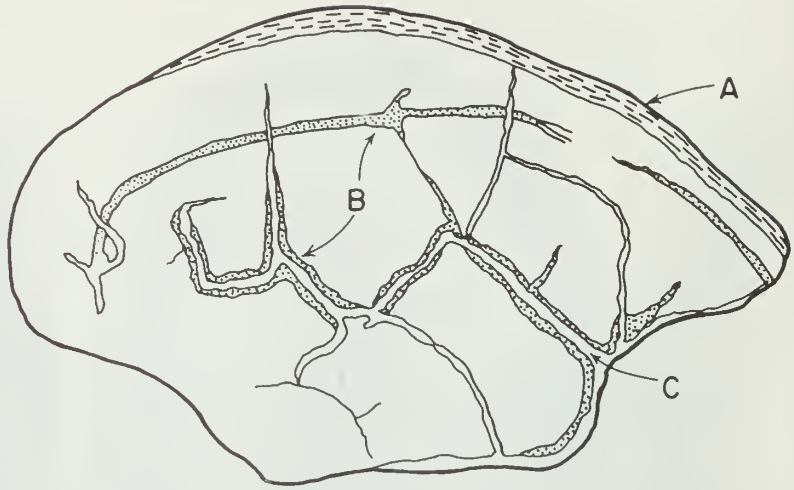

Fig. 5 - Cross section of a sideritic concretion cut parallel to its largest side. A—Rind of gray and brown sideritic material. B—Veins of dark gray, almost black, calcite. C—Gray calcite. The dark gray calcite was deposited early, during the formation of the syneresis cracks that it lines. The lighter gray calcite was deposited later. Actual size.

2. Calcite (B) in solution was introduced into the cavity, which it lined and partly filled. This is evidenced by the calcite crystals that protruded from the walls of the opening. A small amount of calcite later broke away from the cavity walls.

3. Black sphalerite (C) was deposited in the open unfilled part of the cavity and filled it.

4. Syneresis cracks formed in the siderite gel (A) surrounding the calcite-sphalerite core (B, C), and the syneresis cracks filled with calcite (D).

5. The nodule hardened, and subsequent weathering produced a dark brown zone of varying thickness (E).

6. A light gray-brown zone (F) developed on parts of the nodule, possibly as a result of leaching. Events 5 and 6 may have been contemporaneous.

CHEMICAL ANALYSIS OF NODULES

Table 1 gives the results of chemical analyses of six sideritic nodules. Samples NRB 1 and NRB 4 had a chocolate brown exterior rind and a gray interior. The entire specimens were analyzed. The sample labeled "core" was medium brown and came from a diamond drill core in central Illinois from a depth of 230 feet. The Covel Creek sample was medium gray, somewhat weathered, with a comparatively thin, medium brown rind. Sample Coal City 1 was the unweathered gray interior of a nodule from a mine dump in the SW¼ Sec. 32, T. 33 N., R. 9 E., Grundy County; Coal City 2 was the chocolate brown rind of the same nodule.

The chemical analyses (table 1) show that the concretions vary in chemical composition, and analyses of more nodules are needed before generalizations regarding composition can be made. Samples NRB 1 and NRB 4 are roughly the same, as might be expected as they have a common source, but NRB 4 contains more zinc than any other sample. The core sample has the second highest silica content, probably because it contains clay and quartz silt. The Covel Creek sample has the highest phosphorus pentoxide content of the samples. Coal City 2, the rind sample, contains considerably more silica than Coal City 1, the interior

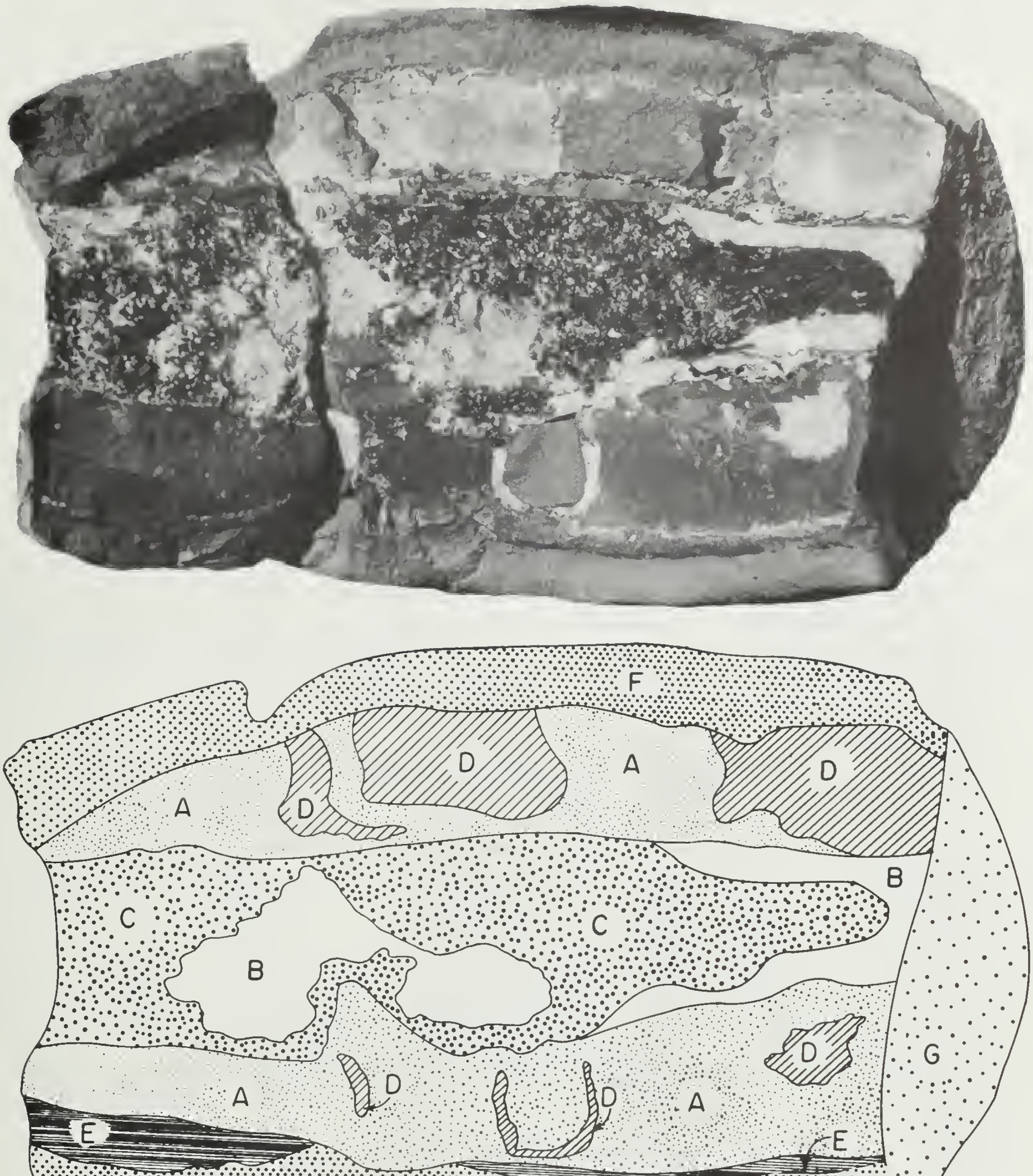

Fig. 6 - Face of a vertically split nodule (X1.2) from the Francis Creek Shale Member, taken from a mine dump in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ Sec. 9, T. 33 N., R. 8 E., Grundy County. The difference in color between zones A and F is believed due to oxidation along an incipient fracture. It does not persist on other fracture surfaces. The components in the photograph are identified in the drawing as follows:

A. Original nodule, inner sideritic zone.

B. Calcite, unrelated to syneresis cracks.

C. Black sphalerite.

D. Calcite related to syneresis cracks.

E. Brown zone.

F. Original nodule, outer sideritic zone.

G. End formed by breakage along syneresis crack.

TABLE 1—CHEMICAL ANALYSES OF SIDERITIC NODULES*

Constituents	NRB 1	NRB 4	Core	Covel Creek	Coal City 1	Coal City 2
			Percentage by weight			
Silica (SiO_2)	3.95	2.60	17.7	8.83	7.08	18.04
Alumina (Al_2O_3)	2.22	1.94	6.43	3.23	2.57	5.42
Iron oxide (Fe_2O_3)	48.1	55.5	39.3	38.4	53.5	56.4
Manganese oxide (MnO)	0.60	0.68	0.47	0.43	0.46	0.60
Magnesium oxide (MgO)	4.15	3.56	3.85	5.48	2.50	2.74
Calcium oxide (CaO)	8.36	3.18	3.57	10.0	2.30	5.41
Sodium oxide (Na_2O)	0.03	0.04	0.14	0.10	0.16	0.07
Potassium oxide (K_2O)	0.52	0.35	0.87	0.85	0.40	0.86
Phosphorus pentoxide (P_2O_5)	2.28	0.42	0.65	3.81	0.83	0.34
Sulfur (S)	0.07	< 0.01	< 0.01	0.13	1.19	0.02
Carbon dioxide (CO_2)	31.44	34.14	26.71	27.49	32.03	9.47
			Parts per million			
Chromium (Cr)	8	8	62	24	14	58
Lead (Pb)	27	74	41	25	162	24
Zinc (Zn)	196	346	248	242	288	72
Vanadium (V)	16	26	92	36	24	63
Copper (Cu)	12	20	36	14	20	18
Nickel (Ni)	6	7	18	11	13	26

Remarks: Ppm values were obtained by comparison with silica-alumina matrix standards. Zn average deviation from mean = $\pm$ 11 percent.

Method: Na_2O was determined by flame photometry with acid solution. CO_2 was measured gravimetrically. Comparison was by ultraviolet. Photometrically measured; matrix compensated and corrected by internal standard.

* Analyses by Analytical Chemistry Section, Illinois State Geological Survey.

sample, but the reverse is true for the carbon dioxide content. The percentages of lead and zinc are higher in the Coal City 1 sample than in the Coal City 2; sample 1 also contains the largest amount of sulfur, equivalent to 4.4 percent pyrite.

The comparatively high percentages of phosphorus pentoxide found in NRB 1 and Covel Creek samples may be caused by fecal material, some of which was recognized in the thin section of one of these samples. Brown (1937) showed that fecal pellets from *Halymenites* (*Ophiomorpha*) burrows contain phosphate. Zangerl et al. (1969) recognized from 2 to 14 percent phosphate in some concretions from the Fayetteville Shale of Arkansas, supporting the identification of the core materials of those concretions as fecal in origin. They also suggested that feces served as nuclei for some of the concretions they described.

X-RAY DIFFRACTION ANALYSIS

Powdered, unoriented portions of the same samples that had been analyzed chemically were subjected to X-ray diffraction analysis. The instrument used was a Norelco XRD equipped with a monochrometer, which greatly reduces the undesirable secondary iron fluorescence. No data were procured for clay minerals, which are known to be present in small amounts but are not detectable in samples prepared in this way. Results are given in table 2.

TABLE 2—X-RAY DIFFRACTION ANALYSIS

Sample	Constituents
NRB 1	Siderite and a little quartz
NRB 4	Siderite and a little quartz
Core	Siderite; considerable quartz
Covel Creek	Mainly siderite; other major constituents are calcite and quartz
Coal City 1	Mainly siderite; a little quartz
Coal City 2	Quartz and hematite

THIN SECTIONS

Thin sections were made of several nodules. Sparry calcite could be recognized along syneresis cracks, and in other parts of the sections a scattering of silt-size quartz grains, pyrite, carbonaceous material, and, in some specimens, white mica could be recognized. For the most part, however, the sections consisted of a dense, brown to gray, very fine-grained groundmass. Individual components showed extreme birefringence, indicating that the material is a type of carbonate.

X-RADIOGRAPHY

Several nodules were examined with a Picker Industrial Mini-Shot X-ray unit in an effort to determine the presence of stratification, biogenic structures, mineral replacement, or organic concentrations. The X-rays were uniformly absorbed, indicating that the nodules are very dense and homogeneous. No stratification or biogenic structures were detected.

SUMMARY AND CONCLUSIONS

Sideritic concretions from gravel, mine dumps, till, shale, and diamond drill cores were investigated. The work done thus far has produced the following picture of this type of concretion.

The concretions studied consist principally of siderite and smaller amounts of clay minerals, quartz silt, and, in some specimens, mica. Also present in some nodules are calcite, limonite, and, less commonly, pyrite or sphalerite.

Concretions dug from shale outcrops are likely to be gray and have only a thin oxidized rind. The interior mass in some, possibly in many, may have calcite-filled cracks.

Weathering of sideritic concretions involves conversion of the siderite to hydrated iron oxide, which produces color banding resulting from the variations in the nature of the oxide and/or the amount of iron oxide present. In sideritic concretions in some gravel deposits, weathering is thought to produce a more or less hollow pebble with a hard outer rind enclosing a residuum of material that occurred in the original siderite of the concretion. Remnants of iron-rich zones formed within the concretion during weathering may also be present.

Flat exterior surfaces on nodules, especially surfaces at or nearly at right angles to their longest dimension, are likely to be the result of breakage along calcite veins believed to be filled syneresis cracks.

Large egg-shaped sideritic concretions seem more likely than small flat ones to have unusual interior structures or mineralization.

The data relating to the characteristics and occurrence of sideritic concretions in various types of deposits in Illinois revealed in this brief investigation suggest that further studies of the concretions would be worthwhile.

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